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16. ABSTRACT

Sudden Infant Death Syndrome (SIDS) has been associated with higher rates of maternal smoking(1) and higher body lead content(2) of SIDS victims compared to control infants, matched for age and sex, who died of other causes. Hoppenbrouwers et al.(3) demonstrated a temporal relationship between the seasonal pattern of SIDS (maximal in cold seasons, minimal in warm seasons) and the seasonal (winter) increase in ambient carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and lead (Pb) in Los Angeles County, California.

Because infants in the first year of life spend most of their time indoors, and maternal smoking would add to the ambient levels in the home, it is the indoor levels of CO and Pb in the nursery that are of most immediate concern.

Hoppenbrouwers et al.(3) and Goldstein(4) pointed out that in the northern hemisphere, winter pollution maxima are associated with temperature minima and that perhaps the low temperature rather than the high pollution may be the factor of interest. To test the hypothesis that winter low temperatures were more important than winter high pollutant concentrations, the Massachusetts Vital Statistics(5) for the years 1978-1980 were examined. Massachusetts has a larger temperature difference from summer to winter than Los Angeles, so the ratio of SIDS incidence in winter to SIDS incidence

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A POSSIBLE RELATIONSHIP OF SUDDEN INFANT DEATH SYNDROME TO INDOOR AIR QUALITY

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Introduction

Sudden Infant Death Syndrome (SIDS), which has a unique age distribution, has been associated with lower parental socioeconomic status(15) higher rates of maternal smoking(3) and higher body lead content(6) compared to non-SIDS infants, matched for age and sex, who died of other causes. Hoppenbrouwers et al.(10) demonstrated a temporal relationship between the seasonal pattern of SIDS (maximal in cold seasons, minimal in warm seasons) and the seasonal (winter) increase in ambient (outdoor) carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and lead (Pb) in Los Angeles County, California. Because infants in the first year of life spend most of their time indoors, and maternal smoking would add to the ambient levels of pollutants in the home, it may be the indoor levels of air pollutants in the nursery that are of most immediate concern. A model that relates the SIDS age distribution to an air pollution effect is presented.

The SIDS Age Distribution

The average SIDS incidence of 2 cases per 1000 live births is characterized by a distinctive age pattern: minimal in the first week after birth, maximal between ages of two and three months, followed by a rapid decline by the age of six months. This pattern is in the SIDS ages from all reporting jurisdictions as shown in Table 1. Although legal requirements for autopsies and definition of SIDS may vary between reporting units, the persistence of this age pattern between countries has led to the hypothesis that SIDS is a single disease entity with many contributing factors (5, 14).

A Probability Model for the Age Distribution of SIDS

One explanation for the unique age pattern of SIDS is that SIDS probability may be proportional to the intensity of three independent physiological danger factors associated with SIDS that can occur simultaneously in a susceptible infant. Three such possible factors are: 1) an increasing uptake potential for CO with

Table 1. SIDS Age Distributions from Four Countries

Monthly Period	G.B. (N.Ireland)	New Zealand	West Germany	USA Mass.	USA Wash.
Reference	(7)	(16)	(1)	(13)	(3)
0-1	9*	3	7*	20	19
1-2	30	14	32	59	107
2-3	31	25	43	47	113
3-4	28	14	49	29	73
4-5	14	11	32	12	49
5-6	12	5	24	11	31
6-7	6	8	19	9	11
7-8	4	3	16	4	8
8-9	2	2	12	4	7
9-10	5	0	7	1	3
10-11	4	1	7	3	3
11-12	2	0	8	2	1
12-18	1	0	16	3	0
18-24	0	0	10	1	0
24-30	0	0	10	0	0
Totals	148	86	292	205	425

*Recomputed from incidence data given in nonmonthly intervals

age to form COHb which enhances hypoxia and may affect the central nervous system; 2) an increasing body burden of Pb with age, which may interfere with neurotransmission; and 3) a decreasing rate of prolonged periodic breathing and apnea with age. If these 3 reported tendencies (2, 6, 11) are modeled as increasing risks with age t of form $A(1-e^{-at})$ and $B(1-e^{-bt})$, and a decreasing risk of apnea with age of form Ce^{-ct} their product forms a difference of exponentials that is known as a pseudo-lognormal distribution (PLD). If the probability of SIDS (pSIDS) is proportional to this product, then

$$pSIDS = ABC\,(e^{-ct} + e^{-(a+b+c)t} - e^{(a+c)t} - e^{-(a+b)t}) \qquad (1)$$

Figure 1 is an application of the PLD model (12) to the USA(3) SIDS data from Table 1 with a comparison to a lognormal model for SIDS ages proposed by Raring (14). Both models, with parameters determined by the method of moments, were not rejected as adequate fits of these data ($p > 0.01$).

The Effect of Low Temperature

Hoppenbrouwers et al.(10) and Goldstein(8) pointed out that in the northern hemisphere, winter pollution maxima are associated with temperature minima and that perhaps the low temperature rather than the high pollution may be the factor of interest. To test

the hypothesis that winter low temperatures were more important than winter high pollutant concentrations, both the Massachusetts Vital Statistics(13) and Massachusetts Air Quality Data Reports for the years 1978-1980 were examined. These data are compared to similar Los Angeles County data reported by Hoppenbrouwers et al.(10) as shown in Table 2.

Table 2: Comparison of SIDS Incidence Between LA and Massachusetts

Month of Death	No. of SIDS(10) LA County, CA 1974-77	No.of SIDS(13) Massachusetts 1978-80	Avg.of Daily 1-hr. Maxima LA County,CA	Avg.of Daily 1-hr. Maxima Boston**
Feb.-May	237	75	17.5 ppm	12.1 ppm
June-Sept.	157	56	17.7	10.5
Oct.-Jan.	299	74	27.6	13.0
Temperature Range of Avg. Daily	+8°C to 30°	-5°C to 24°C*		

*Logan Airport, Boston, MA **Kenmore Square, Boston, MA

Massachusetts has a larger temperature difference from summer to winter than Los Angeles, so the ratio of SIDS incidence in winter to SIDS incidence in summer would be expected to be higher in Massachusetts than in Los Angeles if temperature is the controlling factor. These data show that Massachusetts, like Los Angeles County, has a minimum SIDS incidence in the summer months. However, during the periods studied, the minimum average daily temperatures in Boston were as low as -5°C, whereas in Los Angeles the lowest average daily temperature only fell to +8°C. If low temperature is the controlling variable, the winter SIDS/summer SIDS ratio should be higher in Massachusetts than in Los Angeles, which it clearly is not (1.32 in Massachusetts vs. 1.90 in Los Angeles). Examination of the daily 1-hour CO maxima reported by Hoppenbrouwers et al.(10) for Los Angeles County and for the central Boston monitoring station shows larger CO variation in Los Angeles than in Boston. The Boston data are atypical of Massachusetts since average daily winter temperatures and CO concentrations will be lower in central and western Massachusetts where vehicle density is less and where there is no warming effect of the ocean. It is recognized that ethnicity and parental socioeconomic status are important covariates that differ between L.A. and Massachusetts and the seasonal increase in infection may also vary between L.A. and Massachusetts. With these caveats, it would appear that the minimum average daily temperature (which is well above freezing (0°C) in Los Angeles) may be less strongly associated than pollution variables, with the increase in SIDS rate during the winter.

Measurement of Infant Exposure to Carbon Monoxide

The positive associations of maternal cigarette smoking with SIDS(4) and seasonal air pollution with SIDS(10) are suggestive of a CO linked factor. Since pollutants and agents other than CO are found in cigarette smoke and in ambient air, CO may not be the factor playing a contributing role for SIDS incidence. For example Hassler(9) has suggested that personal hygiene habits of smokers may be less strict than those for nonsmokers, so the children of smokers may be subject to a higher exposure of infectious agents. Indeed, infection rates are highest in the colder seasons when SIDS and air pollution are higher.(15) In order to measure how an infant's exposure to CO is related to maternal smoking, one could monitor CO and temperature in the nurseries of infants whose mothers smoke, with a control group of infants of the same ages whose mothers do not smoke, adjusted for similar ambient CO exposures and types of indoor combustion sources of CO such as gas cooking, kerosene space heaters, and wood stoves. By performing this study over a full year with portable monitors, it would also be possible to measure whether or not the infants' CO exposures in their daily activities (promenade, in a vehicle, at home, etc.) vary in the same seasonal pattern as the incidence of SIDS.

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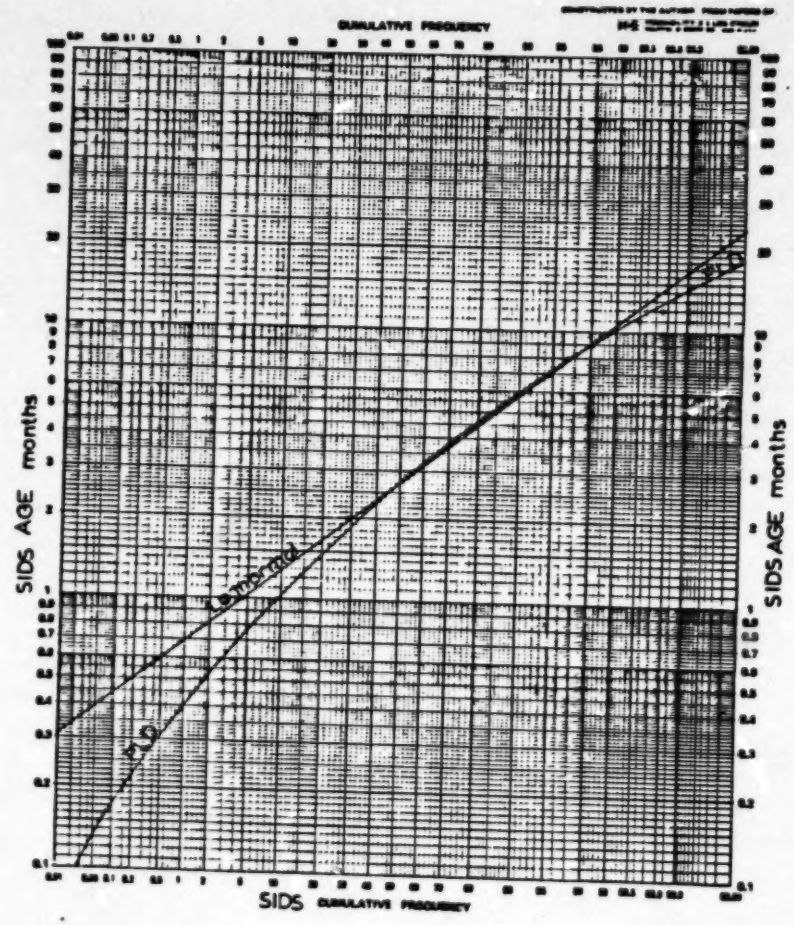

Figure 1 Pseudo-Lognormal (PLD) and Lognormal models of SIDS ages showing similar goodness of fit. The PLD model matches the observed rapid decline of SIDS with age, whereas the Lognormal model tends to overpredict the frequency of SIDS beyond one year of age.